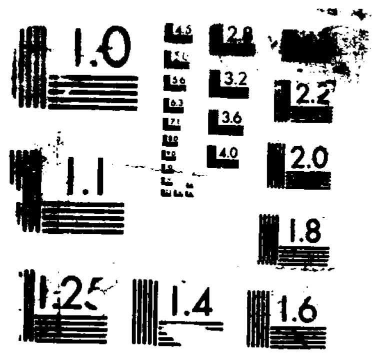
AD-A188 427 SOFT MAPS FOR US ARMY ELECTRONIC MAP BACKGROUND APPLICATIONS(U) ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA D R CALDWELL ET AL 21 JAN 87 ETL-R107 1/1

UNCLASSIFIED F/G 8/2 NL



MICROCOPY RESOLUTION TEST CHART

8c. ADDRESS (*City, State, and ZIP Code*)	10. SOURCE OF FUNDING NUMBERS			
	PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (*Include Security Classification*)

SOFT MAPS FOR U.S. ARMY ELECTRONIC MAP BACKGROUND APPLICATIONS

12. PERSONAL AUTHOR(S)

DOUGLAS R. CALDWELL AND DAVID J. SCOTT

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (*Year, Month, Day*)	15. PAGE COUNT
RESEARCH	FROM ________ TO ______	21 JAN 87	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)

maps, electronic displays, raster
Digital Terrain Data

SOFT MAPS FOR U.S. ARMY ELECTRONIC MAP BACKGROUND APPLICATIONS

Douglas R. Caldwell and David J. Scott

Systems Concepts Branch
Concepts and Analysis Division
U.S. Army Engineer Topographic Laboratories
Fort Belvoir, VA 22060-5546

ABSTRACT

Background maps for geographic referencing and situation status have emerged as the U.S. Army's number one requirement for electronic displays in support of operational systems. Analog video, digital raster, and digital vector data all provide viable alternatives for the development of background maps. This paper reviews U.S. Army applications requiring electronic background maps, examines alternative approaches for producing electronic maps, and focuses on the issues associated with soft maps (raster scanned images of hardcopy products). Soft maps are proposed as a method of quickly developing a digital background map product with wide area coverage.

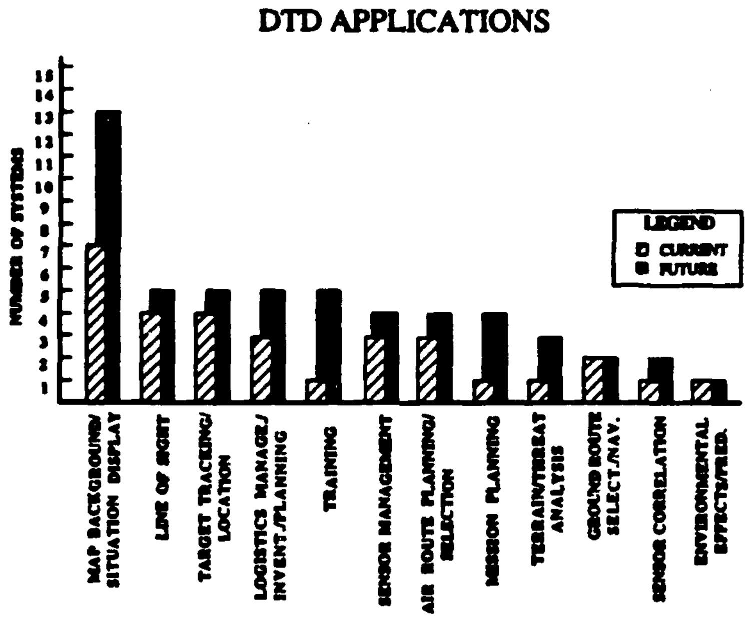
INTRODUCTION

Recent surveys of Army users suggest the need for an electronic product with the information content of a 1 50,000 scale topographic map or 1:250,000 Joint Operations Graphic (JOG). The products would provide background information which can be geographically referenced and used as a base to overlay application-specific data. The map data would remain static with limited manipulation, while the application-specific information would change dynamically. This map background display could be used for a wide variety of applications, including target tracking and location, logistics management and inventory planning, training, sensor management, mission planning, or threat analysis.

Map background data requirements could possibly be fulfilled by analog video, digital raster, or digital vector data. Digital raster data has the greatest potential for quickly producing a wide area coverage database by converting the large inventory of hard copy products to digital soft maps. Analog video production could produce wide area coverage quickly, but generates a less flexible analog product which is cumbersome to use. Digital vector data bases actually produce a product with greater flexibility than required for a static display, but collection of the data is time consuming and expensive with current technology. Additionally, symbolization software is needed to generate a display replicating the hardcopy equivalent.

ARMY SYSTEMS REQUIRING ELECTRONIC MAP DISPLAY

The U.S. Army has assessed near-term (FY 93 or sooner) Digital Terrain Data (feature and elevation information) requirements for tactical systems. The survey identified near-term requirements, analyzed the requirements, and outlined emerging issues. The applications ranged from line of sight calculations using elevation data to environmental effects prediction using elevation data and attributed feature data. Surprisingly, the number one application was for a map background or situation display.



Army Digital Terrain Data Applications
Figure 1

ASSESSMENT OF CURRENT AND PLANNED PRODUCTS TO MEET ELECTRONIC MAP DISPLAY REQUIREMENTS

The electronic background map is intended solely to provide the geographic frame of reference over which the user can overlay system-specific information. The selection of a video-based, raster scanned, or attributed vector data for a near-term electronic map database depends on the present and anticipated availability of data, difficulty in maintenance, and desired degree of flexibility required when using the data. The Defense Mapping Agency (DMA) currently produces a video disc product and attributed vector databases in the form of a prototype World Vector Shoreline (WVS) and Digital Feature Analysis Data (DFAD). A raster scanned hardcopy product database has been proposed to support the Marine AV-8B (Harrier) as a replacement for the moving filmstrip product.

Video Maps. DMA is producing a series of 39 video discs providing coverage worldwide. The set will contain 100% of the Operational Navigation Charts (1:1,000,000 scale), Tactical Pilotage Charts (1:500,000 scale), and Joint Operations Graphics (1:250,000 scale), with limited coverage of Topographic Line Maps (1:50,000 scale) and City Plans (nominally 1:12,500 scale but variable). The product is generated by photographing hardcopy maps with a video camera and storing the series of NTSC video images on a master disc from which copies are made. The discs can contain up to 54,000 images or video pictures of the printed maps. The source maps are photographed in predetermined fields of view (see Table 1) to simulate zooming and with 50% E-W overlap and 30% N-S overlap.

Scale	Field of View
1:500,000 through 1:30,000,000	3" X 2.25"
1:3,000 through 1:250,000	3" X 2.25"
	6" X 4"
	8" X 6"
City Plans and Graphics	3" X 2.25"
	6" X 4"
	8" X 6"

Fields of View for Video Disc Map Images[1]
Table 1

DMA promotes the video map product as a briefing tool and plans to produce a limited quantity of the series of discs.

Video maps are less flexible than attributed vector or soft maps. Manipulation of the images is limited, extensive control is required for geographic referencing, and updating is more difficult. Zooming and panning are accomplished by selecting another frame on the disc which has to be photographed in advance. If the desired zoom or pan is not considered when the disc is made, it won't be available when the disc is used. This leads to redundant recording of map data. A frame grabber can be used to digitize the image, essentially creating a soft map. This digitized image can be manipulated using standard image processing techniques. Geographic referencing of video data requires the centerpoint coordinates, field of view, and laser disc location be available for each frame on the disc. This information is stored on a floppy disc which accompanies the product. The laser disc must be remastered to update information.

---

1. Spidel, David L., "DMA Video Disc Efforts" in Report of Proceedings for the 10th Annual DoD Mapping, Charting, and Geodesy Conference, 1985. (Defense Mapping Agency: Washington, DC) 1985. P. II-103

Attributed Vector Maps. DMA currently produces two attributed vector products, the prototype World Vector Shoreline (WVS) and Digital Feature Analysis Data (DFAD). WVS contains digital coastline data at variable scales from 1.250,000 to 1:12,000,000 (with final scales to be determined), while DFAD primarily contains radar significant features. DFAD data contains information on surface features only, omitting names, boundaries, and significant underground features. DFAD Level 1 Edition 1 contains radar significant features at a scale equivalent of 1:250,000. DFAD Level 1 Edition 2 contains both radar significant features and major lines of communication (even if not radar significant). Both DFAD Level 1 products are compiled from imagery. DFAD Level 1C is compiled from map source and contains a limited number of radar significant features and lines of communication at the 1:250,000 scale.

The U.S. Army is currently negotiating with DMA on a specification for Tactical Terrain Data (TTD). This is a 1:50,000 scale product with the information content of a topographic line map, the Tactical Terrain Analysis Data Base, a Close Combat Chart, and Digital Terrain Elevation Data (Level II). Production of TTD is not anticipated until the mid-1990s.

U.S. Army soldiers have expressed an interest in having a product that replicates the existing 1:50,000 scale topographic map and 1:250,000 scale Joint Operations Graphic which would be identical to the hardcopy product carried in the field. This attitude may change with increasing exposure to digital products, but the use of attributed centerline data for symbolized background map displays requires real time symbolization and display software and hardware which does not currently exist.

Neither WVS nor DFAD meets the U.S. Army requirement for background map information at a 1:50,000 scale. Both the scale and content (even at the 1:250,000 scale) of the digital products are insufficient to provide the information needs for tactical background information. TTD will meet the U.S. Army's long term requirement, but will not be available or usable in the near-term.

Soft Maps. The soft map is a digital raster data base of scanned map images. The Defense Mapping Agency is currently developing a specification for a scanned map data to support the Marine AV-8B. The product will replace the traditional cockpit filmstrip map product with a digital equivalent.

A soft map (not necessarily the AV-8B map) could support the U.S. Army's requirement for background map information. While DMA currently does not produce soft map products, it is anticipated that they can be produced quickly and efficiently from the large base of existing hard copy products without the significant collection requirements associated with attributed vector data. The existing 1:50,000 scale and 1:250,000 scale hardcopy products could be converted by scanning, editing, and reformatting

the source. A raster format soft map would be compatible with imagery databases and allow the merging of the two.

Soft map data would allow significantly greater flexibility than video maps, but less than attributed vector maps. Zooming and panning can be smoothly accomplished within a single database via hardware or software, but isolation of individual map features would not be possible. Updating could be easily accomplished by transferring new patches of data to replace outdated information. This would be possible as long as an updatable media is used to store the information.

ISSUES RELATING TO SOFT MAPS

Because soft maps currently are not produced, there are a number of issues that need to be resolved before a product specification can be developed. These issues relate to the content, resolution, storage requirements, geographic referencing scheme, and distribution media.

Content. The content of the soft map may vary depending on the source material. The final printed product, color separates, or feature separates may be scanned. The choice affects the ease of production and flexibility of the final product.

Final Printed Product. The final printed product can be scanned and the amount of red, green, and blue in each pixel recorded. The data can be digitized directly using a CCD scanner with three filters. This information can be stored and directly fed into an RGB monitor to produce a digital display of the original hardcopy map. Advantages of scanning the final printed product are the rapid acquisition of data and direct usability of the product by RGB display systems. The main disadvantage is the lack of flexibility for decluttering the display and selecting the features. If a certain RGB value or range is turned to the display background color, there will be "holes" of background color in the display. In addition, color variations among the printed sheets will carry through to the digital displays.

Color Separates. The composited color separates used for printing a map can be scanned individually as binary images and later recombined so the presence of each separate at a pixel location is recorded. For a 1:50,000 scale topographic line map there are 5 color separates, one each for the red-brown, brown, green, blue, and black printing colors. For a 1:250,000 scale Joint Operations Graphic there are 10 color separates, with one each for black, gray, red-brown, and green, and two each for blue, brown, and yellow. Scanning the separates gives the user some flexibility in decluttering the image. As an example, the red-brown separate on a 1:50,000 scale map contains the built-up area tints, boundary overprint, contours, contour values, mine features, cuts, fills, levees, earthen dams, sand, distorted surfaces, gravel, dunes and mounds. This level could be turned

off, greatly decluttering the sheet without creating "holes" of background clutter, because multiple values per pixel (from the separates) would be permitted. Additionally, color separates could be combined to create an RGB image. The disadvantage of this approach is that each color separate contains multiple features. Also, production costs for separates could exceed costs for capturing data from the final printed product.

Feature Separates. Feature separates represent the most flexible alternative for scanning traditional map products. Feature separates are collected for each class of feature and combined into color separates for printing. There are over 50 feature separates for a 1:50,000 scale map and over 90 separates for the 1:250,000 scale Joint Operations Graphic. Not all separates are used on every map. Approximately 10 to 30 separates would be used for a typical 1:50,000 scale map.

Feature separates provide the greatest flexibility. The separates could be combined to create a color composite or RGB display. Taking the names separates would allow one to combine the names from the scanned map with an orthophoto, quickly creating an annotated photomap. Some of the separates like the contour lines and contour values could be combined to form a composited feature separate. Different feature separates could be combined to produce new information. As an example, the potential locations of bridges could quickly be identified by intersecting the drains with the roads. In addition, feature separates could be used to generate a vector database. Feature separates are the closest approximation to attributed vector information, although they are divided into classes of features, not individual features. It would be a straight forward operation to vectorize the raster scanned separates.

The availability of feature separates for scanning would be a major issue related to their use. After the feature separates are composited as color separates, they are sometimes discarded. If available, the time needed to scan the large number of separates could be extensive.

Resolution. The resolution at which to scan the hardcopy products is an area that will require further investigation. Given the "rule of thumb" that one should scan at twice the resolution of the smallest feature in order to capture the detail, a 1:50,000 scale topographic map should be scanned at 0.002" to capture the 0.004" linework. However, it may be possible to obtain satisfactory results with lower resolution scanning. If the scanned data is to be used for printing hardcopy products, higher resolution data may be needed. The selection of the final resolution will be a compromise balancing the users' needs and the economics of production and storage.

Storage. The storage requirements for scanned map data will vary depending on the content (final printed product, color separates, or feature separates), resolution, and data compression scheme.

Final Printed Map. See Table 2 for the storage requirements for topographic maps scanned at an uncompacted 24 bits/pixel (8 bits red, 8 bits green, and 8 bits blue). Maps containing Fort Bragg were used to size the samples.

Resolution(LPI)	1:50,000 (22" X 18")	1:250,000 (29" X 18")
1000	9.5 Gbits	12.5 Gbits
500	2.4 Gbits	3.1 Gbits
250	0.6 Gbit	0.8 Gbit
100	95 Mbits	125 Mbits

Storage Requirements for 24 Bit/Pixel RGB Data
Table 2

With 24 bits/pixel, it would be possible to create 16,777,216 different colors. Because only 5 colors are used to print the original 1:50,000 scale map and 10 colors to print the 1:250,000 JOG, such a large color space for scanning the sheets seems excessive. The color space could be reduced to compact the data without significantly impacting the overall presentation.

Color Separates. Scanned color separates could reduce the information to 5 bits/pixel to store the 5 color separates of the topographic line map or 10 bits/pixel to store the 10 color separates of the JOG. The presence or absence of each separate would be recorded for each pixel and stored in a single file. The binary data for each separate would have to be converted to RGB for display. Priorities would need to be assigned to the different separates similar to printing priorities.

As an alternative approach, 1 bit/pixel for separate information could be used to keep the information for each separate in different files. Significant data compaction in the form of run length encoding or quadtree conversion could be applied to these binary files. They would have to be uncompacted and converted to RGB for display.

Feature Separates. Feature separates could be stored in a manner similar to color separates. The large number of feature separates would make storing the information for all feature separates in a single pixel undesirable, but run length encoding or quadtree compaction could be applied. The feature separate information would also have to be converted to RGB for display.

Not enough information on the storage requirements for color composites, color separates, or feature separates is known at this time. The development of prototypes and additional

experimentation is needed to reduce the volume of information while maximizing the utility and flexibility of the digital product.

Geographic Referencing Scheme. One key advantage to the scanned raster map over the video map is the ability to geographically reference each pixel without redundant storage of geographic locations. The pixels may represent cartesian coordinates referenced to the projection of the scanned map, a UTM coordinate system, or a geographic coordinate system (spaced at even arc seconds). The U.S. Army traditionally uses UTM coordinates, but this does not lend itself to a seamless database. Selection of a seamless geographic referencing system raises the age old problem of mapping the curved earth on a flat plane. This is especially critical for planar coordinate displays in order to reduce transformation calculations.

Distribution Media. The choice of the distribution media will also affect the usability of the product. DMA currently distributes its digital products on nine track tape, but the large volume of data required for soft maps suggests the advantage of optical disks, such as CD-ROM. Distribution of the data on both magnetic tape and optical disks may be necessary in the near future to accommodate fielded systems which are not configured with optical disks as well as to plan for the incorporation of higher density mass storage systems in the future.

CONTROL OVER REQUIREMENTS

The Army has made significant progress in establishing needed controls for emerging digital mapping requirements such as the soft map. It recently established a single point of contact for technical expertise on all digital mapping and terrain data. The new Concepts and Analysis Division of the U.S. Army Engineer Topographic Laboratories now performs a vital service to Army developers, their contractors, and field commanders.

Requirements for new support using digital maps and terrain data are passed through the Concepts and Analysis Division of USAETL and the Assistant Chief of Engineers to the Deputy Chief of Staff for Intelligence for assignment of priority and resources before being stated as an Army requirement to DMA. Once a new product has been established as standard by DMA, geographic area requirements for Army components are processed through Unified & Specified Command or Service channels, as appropriate. Further controls are expected after July 1987 from an initiative by the DOD Joint Requirements Oversight Council to start a system of MILSTANDARDS for digital mapping, charting, and geodesy.

CONCLUSIONS

The U.S. Army has fourteen tactical systems to be fielded before 1993, as well as additional requirements in the analysis,

training, and research and development areas, which will require some form of electronic background map or situational display. The display will be static, although some flexibility for decluttering is desirable. Soft maps, or scanned hard copy products, offer the best solution to obtaining wide areas of coverage in a short time frame and at the same time permitting limited manipulation of the data. The exact form of the product is difficult to predict at this time. Additional analysis of the content (RGB from the final printed product, color separates, or feature separates), resolution, storage format, geographic referencing scheme, and media are needed to determine the optimal product design. Prototypes should be developed and evaluated before adopting a specification to meet U.S. Army requirements.

REFERENCES

Defense Mapping Agency. Defense Mapping Agency Product Specifications for 1:50,000 Scale Topographic Maps of Foreign Areas. (1980) 1st Ed. Washington, DC: Defense Mapping Agency

Defense Mapping Agency. Defense Mapping Agency Product Specifications for Joint Operations Graphics Series 1501 and Series 1501 Air Scale 1:250,000. (1976) 4th Ed. Washington, DC: Defense Mapping Agency

Spidel, D. "DMA Video Disc Efforts" in 10th Annual DoD Mapping, Charting, and Geodesy Conference Report of Proceedings. (1985) Washington, DC: Defense Mapping Agency

Johnson, R. "Electronic Maps and Terrain Data," Information Paper (1987) Washington, DC: Department of Army Headquarters

END
DATE
FILMD
3-88
DTIC